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THIS ISSUE

With Magellan at Venus, *NASA Activities* takes time to review the planet and human efforts to learn more about out mysterious neighbor. See **"The Unveiling of Venus"** in this issue.

NASA VISIONS give us a Voyager view of our home solar system like we have never seen before. It's a small world!

Spherical aberration in the optical system of the Hubble Telescope and the ensuing hubbub should cause us to take stock of what NASA is and how we approach problems. **Read "Hubble's Trouble: NASA's Response — A Special Report"** in this issue.

Ulysses reaches for the sun. No other spacecraft has plied solar-polar space to gather data scientists hope will bring surprises. **JPL Project Scientist Ed Smith provides us with an inside view of Ulysses.**

75 years of NACA/NASA aeronautical reseach is saluted with a review of aeronautical contributions and a paen to flight research: **"Pushing the Envelope".** — *Ed.*

Next Issue:

The Space Shuttle

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Highlight of NASA's Exhibit at the Experimental Aircraft Association's 1990 fly-in, Oshkosh, Wisc., the X-29 Forward Swept Wing research aircraft debuts on its first trip out of Southern California. X-29 pilots and researchers were on hand to answer questions.

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COMMENTARY

Why Space?

By Eugene A. Cernan, USN (Ret.)
Commander, Apollo XVII

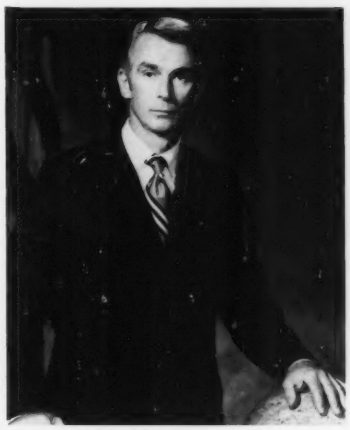
(From a July 4, 1990 address.)

December 14, 1972, I left mankind's final footsteps of Apollo on the surface of the moon. As Jack Schmitt and I departed, we echoed the words that some day "we shall return"—that Apollo XVII was "not the end, but the beginning" of a whole new era in the history of mankind. But what we did not anticipate was that the "beginning" would be a generation in coming and that the future might well be challenged by other than Americans.

But if Apollo was the beginning, what about the future? Where are the dreams and the visions today, and where is the resolve, the action that allowed us to learn, to live, and to work in space and ultimately to venture a quarter of a million miles away from home? Is it still possible for an American President to take as bold a step as John F. Kennedy did in 1961 when he set this country's sight on the moon—the day this country dared to become a space-faring nation?

I believe it is, but only when our leaders in Congress accept the reality that space is not a luxury, but a necessary ingredient to our position of world leadership and to the economic future well-being of each and every American.

My hopes soared when President Bush announced last July 20th—the 20th Anniversary of one of mankind's greatest achievements in history, the footsteps of the first human being ever since the beginning of time to set foot on another world—that we would return to the moon, this time to stay. Could it be that once again we have a President who not only reflects upon the past, but understands the significance and importance of a national commitment to the future? The President recently expanded his space exploration initiative by setting the year 2019 for a manned mission to Mars. No matter what the date might be — 2012, 2019, or 2022, I believe of greater significance is for this nation to have an ambitious yet attainable goal that reaches out a generation into the future–a goal



Eugene A. Cernan

the entire country, both young and old, government and industry, can get our arms around—a continuing national goal that transcends political boundaries—one that isn't challenged, changed, or canceled only to be reborn every four years.

But some in Congress now want to stop our renewed space effort before it even has a chance to be debated. The Congressional Sub-Committee that appropriated money for NASA somehow saw a reason to delete all funds for the President's Space Exploration Initiative. They said that space could wait until next year, as it has waited for each of the last twenty.

But can America wait forever to renew our exploration of space?

A quarter of a century ago, we and the Soviets were the only countries in the world who even dared to dream of going to the moon. Together we owned space. Not so any more. This year Japan launched a probe to the Moon—the first earthly object directed there since the early 1970s. Last year the Japanese established a scholarly journal to publish ideas on how to go to the Moon for economic benefit. A few years from now Japan will launch a series of probes aimed at surveying lunar resources for their own industrial and economic potential.

Clearly many other nations—particularly those known for long term investment and economic success—have targeted space as the growth industry of the 21st century.

But why space—what's in it for us? If we take but a moment and reflect upon history, upon the accomplishments of the past quarter century, upon the impact of space on medicine, communications, computer technology, as well as those things now an integral part of our everyday lives, it is then that we must acknowledge the importance of the foundation of technology from which this nation has flourished. This foundation of technology has been nurtured and has continued to grow for over 100 years, allowing the United States to reach for and achieve greatness as the world leader of civilized mankind today. This technological base has not only allowed us to gain a technical and scientific understanding of the universe in which we live, but to achieve international stature, political leadership, and economic affluence and well-being second to none, anywhere in the world. Today the brightest spot in U.S. balance of trade continues to be the aviation industry. Tens of billions per year pour into this country from our overseas commercial aircraft sales.

This unique situation did not come about by chance, but rather as a result of over eighty years of U.S. investment in research and development. This technological legacy, so important to the past, is equally important to the future— and space is its cornerstone.

Today, there is even more at stake than there was in 1961. Unless we find a vehicle for carrying forward the research and development upon which our economic affluence and world leadership depend, the foundation of which I speak might well crack and begin to crumble. I believe that vehicle is space.

Education is the most far-reaching and crucial problem this nation faces today. Americans everywhere decry our second rate educational standing in the world. The problems are particularly acute in the critical science and engineering disciplines.

It is a well-known fact that the U.S. Space Program provided an enormous impetus and incentive for technical education in the 1960s. Our production of scientists and engineers tracked the increases and unfortunately the decreases in our space exploration effort.

During the 1960s we not only produced outstanding technical people, but the best and brightest from overseas flocked here as well. Now as we approach the challenge of the 21st century, it is a sad commentary that we produce only half as many scientists and engineers, and that over half of those are foreigners who return home to enrich their economic competitiveness, not ours.

Good education requires much more than better facilities, more committed teachers and modern equipment. It takes inspiration for our students to excel, and there is

continued on page 14

Presidential Support

(On July 17, President Bush held a press briefing for the Magazine Publishers of America. He was asked about the space program. His extemporaneous remarks are especially noteworthy — Ed.)

Q. Mr. President, Terry McGraw, McGraw-Hill: Since the completion of the Apollo Space Program the U.S. space program has seemingly struggled for a definitive notion of its mission. Could you comment on your priority the space program has in your agenda, and more specifically, what your expectations are in this new investigation of NASA?

A. The President: One, I have great confidence in Dick Truly, the Administrator of NASA. And so to lay that part of the question to rest, what we are doing is asking him to form an outside committee of the best minds he can find to look to the future. Not to try to assign blame because a mission is delayed getting off the ground. I mean, these shots are highly complex. We have been the leaders in space and I want to see us continue to be the leaders in space.

So the group that was advertised a couple of days ago or heralded as an investigation of NASA is nothing of the kind. I saw the stories and, once again, went semiballistic, thinking, my heavens, how could somebody write this when that is not what the President intends? But I think the Vice President, who is doing a good job as head of the Space Council, clarified that.

In terms of goals, we've got some broad objectives that go far beyond lunar landings now. But the first one obviously would be this space station, but with continued shots back and forth to do the — what's almost becoming journeymen's work in space.

I'm confident we can do it. Obviously, we're in tight budget times, so we've set the goals for Mars and beyond out there many, many years. But I have confidence in NASA. And it's a perilous business I guess anytime you put people up there into space. But the record has been very good.

And yet, I think the management is such a complex — it's such a complex organization that it is appropriate that the Administrator now call on the best minds he can find to see how we're going to meet these next goals and meet them, hopefully, within budget. And I'm talking about the space station; I'm talking about what Sally Ride talked about — Mission to Planet Earth, where we actually utilize to the fullest extent possible space shots and improving matters on Earth. Obviously, the environment comes to mind and agriculture comes to mind. And then taking that third step, how do we organize NASA to meet this big, tremendous management challenge that will come about for this next quantum leap forward — and discuss the cooperation with other nations in all of this.

I mean, as the whole world is changing — and it has dramatically changed — there may be some real opportunities now to do more with the Soviet Union, for example, or with other countries. So all of this requires a new look. And that's what this story was about. ■

INSIDE NASA

NASA's Educational Outreach

By Terri Sindelar, Hq

Know the number of education programs NASA conducts? Would you guess forty? Seventy? One hundred? Before I was assigned the Educational Affairs Division as my public affairs "beat," I would never have guessed 160. Yes, 160 academically and culturally diverse programs.

These comprehensive programs, which parallel the agency's programs, are aimed at sparking students' instinctive interests in airplanes, spacecraft, astronauts, space science and exploration in hopes of drawing students into math and science disciplines.

President Bush previews a "Space Classroom: Assignment the Stars" experiment with teacher Karen Widenhofer and student participants.

An enthusiastic supporter, NASA Administrator Richard H. Truly believes NASA has a vested interest in and national responsibility for improving math and science education. His goal for education is to increase the number of young scientists, engineers and technicians that our country so urgently needs if we are to remain globally competitive. At no time in history has education been so prominent on NASA's agenda.

To meet the challenging education goals set by the President and the Governors, Truly testified June 28 to the Senate Appropriations Subcommittee that NASA needs "to develop more innovative education outreach strategies, while retaining our proven education programs."

The resulting education outreach program, geared for elementary through graduate school, focuses on three areas.

Realizing students can get "turned-off" or "turned-on" at an early age, the first element is to use our unique and exciting aeronautics and space science programs to CAPTURE the elementary and middle school student's interest in science and math. Once the students become curious, our programs then CHANNEL these secondary and university students into science, engineering and technical career paths. But, it's not enough for us to work with students. As the third element of our strategy, we have programs that ENHANCE the knowledge, skills and experiences of teachers and university faculty.

A new team-developed program designed to capture student interest in math and science is the result of bringing together the talents of astronomy mission managers, the STS-35 crew and the education staff. "Space Classroom: Assignment the Stars," is a pilot effort involving a live lesson taught by members of the orbiting Astro-1 crew to the nation's middle school students about the electromagnetic spectrum. After the lesson, students participating at Marshall and Goddard will ask the orbiting crew questions. Space Classroom will be carried on NASA Select TV.

In future NASA Activities articles, we hope to bring you updates on exciting education programs, such as SEEDS, LASER Space Grant, and the expanded use of NASA Select TV, taking place throughout NASA. ■

AGENCY HIGHLIGHTS

The Unveiling of Venus

By Lee D. Saegesser, Hq

(As the Magellan Venus probe begins unwrapping Venus' secrets, we take a look at previous efforts to get to know the mysterious planet. — Ed.)

Venus, the most conspicuous object in the sky, may soon give up some of its long held secrets. Almost four centuries ago, in December 1610, Galileo observed and announced his discoveries of the phases of Venus. Since that time Venus has been very reluctant to reveal many additional secrets.

One could expect that we would know a great deal about this planet, yet such is not the case. As recently as 1951, Arthur C. Clarke, writing in *The Exploration of Space*, said: "Actually, we know practically nothing - not even the fundamental fact of her rotation period, ...the resemblance between our world and Venus virtually begins and ends with size... The face of Venus is utterly featureless - or, to be more accurate, it is forever hidden from us by clouds...What lies below the clouds we can only guess."

In ancient cultures Venus was known by many names. The Babylonians named her Nin-dar-anna, meaning mistress of the heavens. Tai-pe, beautiful white one - was what it was called by the Chinese. In Egypt it was known as Tiourmoutiri the morning star and Ouati the evening star, both meaning"feminine". In Greek it had two names, Hesperos and Phosphoros meaning "west" and "light bearer." The Latin name Venus meant goddess, and later goddess of spring and love.

Unlike any other planet Venus is almost the Earth's twin in terms of density, mass, and size. Its diameter is 7,520 miles and the Earth's is 7,920 miles. The mass and density of Venus is slightly less than that of Earth. Venus is also Earth's nearest neighbor in space after the moon.

Why study Venus, especially by sending spacecraft to the planet? Venus may hold many of the chapters to our understanding the solar system's and Earth's evolution. A detailed, global image of Venus will tell us much about the planet's evolution, environment, and geology. And in turn this will

Planetary Comparisons

	Venus	Earth
Distance from Sun	67.2 million miles	93 million miles
Solar Year	224.7 Earth days	365.26 days
Length of Day	243 Earth days	24.6 hours
Diameter	7,519 miles	7,926 miles
Density	3.0 oz/cu in.	3.2 oz/cu in.
Mass	0.815 x Earth	1
Geologic Composition	metal & silicate	metal & silicate
Solar Radiant Energy	2.3 x Earth	1
Surface Temperature	900 degrees F.	80 degrees F.
Atmosphere	Carbon Dioxide	Nitrogen, Oxygen
Atmospheric Pressure	92 Bars	1 Bar

Venus Probes

1961	Venera 1	USSR	1972	Venera 8	USSR
1962	Mariner 2	US	1974	Mariner 10	US
1964	Zond 1	USSR	1975	Venera 9,10	USSR
1966	Venera 2,3	USSR	1978	Pioneer Venus 1,2	US
1967	Venera 4	USSR		Venera 11,12	USSR
	Mariner 5	US	1982	Venera 13,14	USSR
1969	Venera 5,6	USSR	1983	Venera 15,16	USSR
1970	Venera 7	USSR	1985	Vega 1,2	USSR

enable us here on Earth to learn more about our own small fragile globe.

In recent years radar images of Venus from Earth have shown raised land masses, and suggested peaks and canyons on the surface. It has only been since the beginning of the space age that humans have actually been able to visit this mysterious heavenly body through unmanned scientific spacecraft. There have been 20 trips to Venus by United States and Soviet Union probes carrying low-resolution radar and other sensors.

A few photographs taken during the brief lives of Soviet landers on the surface have shown intriguing and fleeting details of a largely fragmented landscape. Venus' surface is hidden by a very dense atmosphere with opaque clouds.

A U.S. space probe, launched in 1989, with a mission of mapping the hidden surface is named Magellan after Ferdinand Magellan, the Portuguese explorer whose expedition circumnavigated the world in the 1520s.

Magellan was carried into space by the Space Shuttle Atlantis, May 4, 1989. *(See NASA Activities, Feb. 1989 —Magellan: Exploring Venus as Never Before.)* It was then boosted toward Venus by the Inertial Upper Stage on a 15 month voyage. Magellan arrived at Venus August 10th. After approximately two weeks of instrument testing the spacecraft was to have begun mapping Venus on August 28. This primary mapping mission will last for 243 Earthdays, or one Venus day, ending April 18,1991.

Magellan is expected to acquire a wealth of data from its Synthetic Aperture Radar, penetrating the dense cloud cover through to the surface of the planet and mapping 70 per cent of the geological formations. This one instrument will transmit back to Earth more data than all previous planetary missions combined. ■

Minority university officials sign consortium agreement. Deputy Administrator J.R. Thompson represented NASA.

NASA Signs Agreement with Minority Universities

A memorandum of understanding (MOU) between NASA and representatives of a newly-formed academic consortium comprising six minority universities has been signed. The MOU establishes the NASA Space Technology Development and Utilization Program Consortium (STDP), designed to increase minority universities involved in NASA research and technology development.

The consortium includes North Carolina A&T State University, Greensboro; New Mexico Highlands University, Las Vegas; Central State University, Wilberforce, Ohio; Southern University, Baton Rouge, La.; Jackson State University, Jackson, Miss.; and Tuskegee University, Tuskegee, Ala.

"This collaboration creates an infrastructure to enhance and strengthen each university's science and engineering research programs. It also will help increase representation of Blacks, American Indians and Hispanics in these fields. This effort significantly exceeds any previous jointly-pursued minority university initiative," said NASA Deputy Administrator J.R. Thompson.

The infrastructure provides for effective management and technical interfaces with numerous organizations such as NASA program offices and field centers, minority academic institutions, the private sector and the minority business community.

As part of the agreement, NASA will fund seven research projects, 20 graduate student fellowships and 31 undergraduate student scholarships, totalling about $1 million.

Several program benefits include developing a large pool of minority science and engineering undergraduate and graduate students participating in NASA research; increasing opportunities for faculty exchange; providing summer internships, co-op programs and faculty research fellowships with government and industry; providing minority universities with direct interaction with technology-oriented industry and with government; and supporting viable commercial development and technology transfer to industry. ■

Exploration Outreach Launched

Stafford to Lead Group

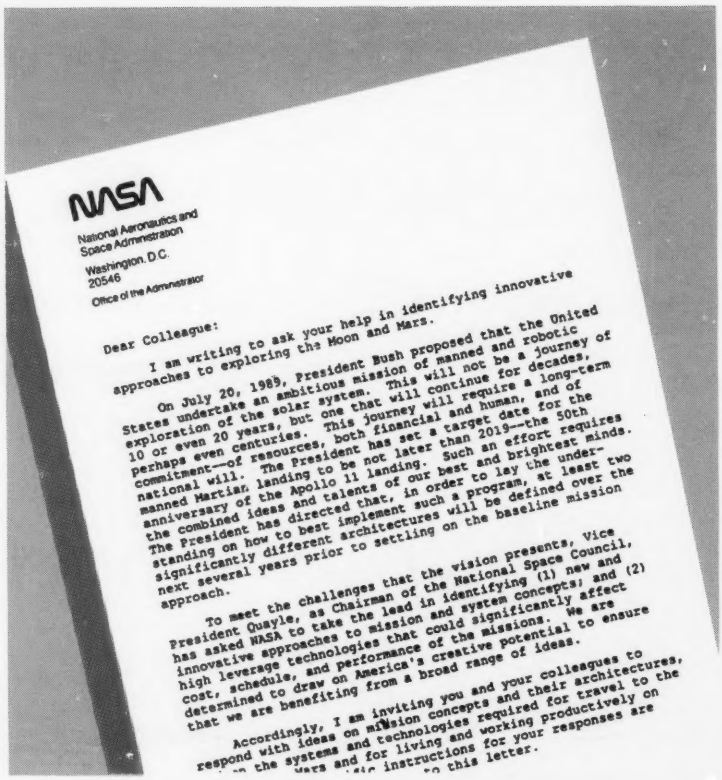
NASA has launched an Outreach Program to seek new and innovative ideas, systems and technologies to carry out the nation's Space Exploration Initiative (SEI). The Outreach Program is in response to Vice President Quayle's request to "cast the nets widely" for new approaches.

Appointed to lead a synthesis group which will play a major role in the Outreach Program is former astronaut Lt. Gen. Thomas P. Stafford, USAF (Retired). This group will survey the innovative ideas and recommend two or more significantly different alternative architectures, as well as technology priorities and early milestones. The group will report to the NASA administrator.

The Outreach Program seeks approaches to mission and system concepts; and innovative, high leverage technologies that could significantly affect cost, schedule and performance for SEI, which sets the future course of the U.S. civil space program.

President Bush announced the SEI on July 20, 1989, the 20th anniversary of the Apollo 11 lunar landing. At that time, he proposed a long-term continuing commitment to complete Space Station Freedom; permanently return to the Moon; and send a manned expedition to Mars. On May 11, 1990, in a speech at Texas A&I University, President Bush declared that before the 50th anniversary of the Apollo 11 lunar landing (2019), "the American flag should be planted on Mars."

NASA Administrator Richard H. Truly said the SEI outreach program is "solid and thorough" and "will leave no stone unturned to reach out to the very best and brightest in our nation." To gather information, concepts and data from the most creative minds in government, industry, academia and elsewhere, Truly said the program takes a three pronged approach. This consists of direct solicitation of ideas, a review of Federally sponsored research, and a study by the American Institute of Aeronautics and Astronautics (AIAA).



NASA
National Aeronautics and Space Administration
Washington, D.C. 20546
Office of the Administrator

Dear Colleague:

I am writing to ask your help in identifying innovative approaches to exploring the Moon and Mars.

On July 20, 1989, President Bush proposed that the United States undertake an ambitious mission of manned and robotic exploration of the solar system. This will not be a journey of 10 or even 20 years, but one that will continue for decades, perhaps even centuries. This journey will require a long-term commitment--of resources, both financial and human, and of national will. The President has set a target date for the manned Martian landing to be not later than 2019--the 50th anniversary of the Apollo 11 landing. Such an effort requires the combined ideas and talents of our best and brightest minds. The President has directed that, in order to lay the understanding on how to best implement such a program, at least two significantly different architectures will be defined over the next several years prior to settling on the baseline mission approach.

To meet the challenges that the vision presents, Vice President Quayle, as Chairman of the National Space Council, has asked NASA to take the lead in identifying (1) new and innovative approaches to mission and system concepts; and (2) high leverage technologies that could significantly affect cost, schedule, and performance of the missions. We are determined to draw on America's creative potential to ensure that we are benefiting from a broad range of ideas.

Accordingly, I am inviting you and your colleagues to respond with ideas on mission concepts and their architectures, the systems and technologies required for travel to the Mars and for living and working productively on ... instructions for your responses are ... to this letter.

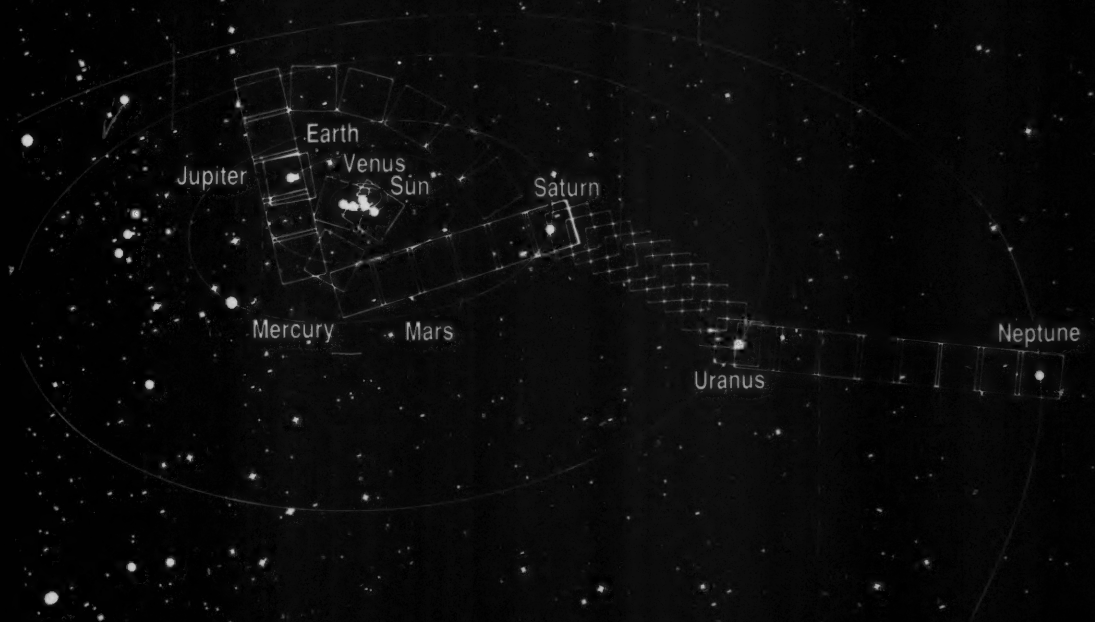
The solicitation effort includes a letter from Truly to organizations that can provide the highest leverage, such as universities, professional societies, associations and others. It also includes an announcement in Commerce Business Daily, which reaches aerospace and non-aerospace industries and others.

The Rand Corporation will conduct an initial screening and assessment of submissions and report to the external Synthesis Group, composed of government and non-government individuals. This group also will receive inputs from the Department of Defense, the Department of Energy and other organizations. The results of this activity will also be made available to the National Research Council for review.

The AIAA study solicited and assessed innovative approaches to SEI from AIAA's 40,000-person membership and technical working groups. ■

Voyager's Portrait of the Solar System

This image of the sun, Earth and Venus was taken by the Voyager 1 spacecraft Feb. 14, 1990, when it was about 32 degrees above the ecliptic plane and 4 billion miles away. It is the first — and may be the only — time that we will ever see our solar system from such a vantage point. The image is a portion of a wide-angle image containing the Sun and the region of space where the Earth and Venus were at the time with two narrow-angle pictures centered on each planet.



Depiction of Voyager 1's multi-frame solar system portrait mosaic.

Hubble's Trouble, NASA's Response

A Special Report

NASA has encountered technical problems in many previous programs. The recent discovery of a spherical aberration associated with the Hubble Space Telescope's mirror system has thrust NASA into the media limelight again — and again it's on the issue of a problem.

At press time, an investigative board had focused its efforts on a maladjusted "reflective null corrector" as a probable cause of the aberration. It will provide a report to the Administrator in the next several months.

How this problem was uncovered and what NASA is doing about it are the subjects of this review, written for NASA Activities by the staff of the Astrophysics Division at NASA Headquarters. — Ed.

Discovery of the Aberration

In late May, 1990, Hubble Space Telescope engineers began the process of bringing the Hubble telescope optical system into fine focus.

After analysis of early Optical Control System data, the engineers calculated secondary mirror movements (tilt, decenter and despace) that should have brought the optical system into almost perfect focus.

Following the execution of these various mirror movements, an image was taken with the Wide Field/Planetary Camera — one of two instruments most sensitive to shifts in focus. When the Wide Field/Planetary Camera image appeared on the screen at the Goddard Space Flight Center, it was very apparent to those present that there had been absolutely no improvement in the image quality.

By mid-June, after further observations, the project staff had acquired a growing suspicion that the problem was really spherical aberration in the Hubble optical system. Computer models generated at the telescope institute in Baltimore were able to match the Wide Field/Planetary Camera images by modelling a Hubble optical system with a known quantity of spherical aberration.

To prove this suspicion, the other instrument sensitive to minute focus changes — the Faint Object Camera — was used to take several images. These Faint Object Camera images matched the Wide Field/Planetary Camera images, which proved the problem was in the optical system and not in the instruments.

Moreover, the Hubble Space Telescope has an additional sensing system called Wave Front Sensors. These sensors are designed to measure small imperfections in the light "wavefront" which result from its path through the optical system.

The Hubble project team was beginning to obtain high enough quality data from these Wave Front Sensors to add further to the growing data base that strongly indicated the Hubble's optical system had severe spherical aberration.

Preliminary Damage Assessment and Announcement

The decision was made on June 26, 1990, to announce the problem to the rest of the world. This decision was reached after meetings with the Associate Administrator for Space Science and Applications, the Deputy Administrator and the Administrator.

After briefing NASA's top management, it was decided to convene a press conference on June 27. That morning, the Hubble program scientist, Dr. Edward Weiler, met with the members of the Hubble Science Working Group, the scientific team which advises project management on issues related to the project. The group includes the investigators, representatives from ESA and the NASA centers and several outside scientists.

The meeting produced a preliminary analysis of the impact to the scientific community.

The assessment indicated that scientific use of the five instruments and Fine Guidance Sensor for astronomy and astrophysics investigations would be limited from moderately to severely depending on which instrument.

Worse hit were the two imaging instruments, the Wide Field/Planetary Camera of Dr. James Westphal, California Institute of Technology, and the Faint Object Camera of Dr. Duccio Machetto and the European Space Agency. These instruments relied heavily on the superfine focusing specifications of the Hubble telescope's optical system and would be limited to being able to accomplish no more than 10 percent of their then scheduled science for the Wide Field/Planetary Camera and no more than 50 percent for the Faint Object Camera.

Impacted much less were the High Speed Photometer of Dr. Robert Bless, University of Wisconsin, and the Faint Object Spectrograph of Dr. Richard Harms and the University of California at San Diego. These two instruments would be able to perform slightly more than half of their scheduled investigations.

Better still was the Goddard High Resolution Spectrograph of Dr. John Brandt of the University of Colorado and his colleagues at the Goddard Space Flight Center. Nearly 75 percent of this instrument's observations could still be made with no loss whatsoever. The Fine Guidance System, used for the astrometric observations which could be used to detect extra-solar system planets, would not be affected at all.

Overall, the impact to the planned science activities of the various Hubble Space Telescope instruments added to a 50 percent loss of the project's scheduled

science observations.

Following the Science Working Group meeting, Dr. Weiler and others from the project office and NASA Headquarters, met with the press in a briefing where the problem was discussed in as much technical detail as was known at the time and the impact to the various science objectives was spelled out clearly.

The challenge of that press conference was for the Hubble team to explain to the press that, though there would be a loss of immediate capabilities for the Hubble program, the loss was only a temporary loss and that NASA would be deferring — not cancelling or losing — the scientific objectives which could not be met at that time. As an example, Dr. Weiler cited the fact that the full imaging capabilities of the Wide Field/Planetary Camera would be regained when NASA launched a second generation version of that instrument aboard a shuttle scheduled for 1993.

This second generation instrument, called the Wide Field/Planetary Camera II, would be built with corrective mirrors which counteract the spherical aberration of the Hubble optical system. With such a mirror, the Wide Field/Planetary Camera II would be able to recover full capabilities in the imaging science discipline and fully complete its scientific observation agenda.

With second generation replacement devices for the spectrograph instruments expected to be ready in 1996, these disciplines would regain the complete set of investigations originally scheduled to be accomplished.

The press conference lasted nearly 90 minutes as reporters sought to understand the exact nature of the impact and the NASA team tried to explain that because the telescope was originally overbooked by nearly 800 percent, no high priority science would be lost, but rather a portion of some specific scientific observations would be deferred until replacement instruments were mounted on the telescope and that these instruments were already either being built or in final design.

Strategy to Maximize Science

Back in the project arena, a subcommittee of the Science Working Group was set up under Dr. Machetto to attempt to maximize the science which could be performed in the near term. Dr. Machetto's subgroup was to study the entire Guaranteed Time Observer science program and find the observations which could not be done with the current Hubble optical problem. Another subgroup was formed under Dr. Robert O'Dell and tasked to develop a list of science targets which could be performed easily with the Hubble's current configuration.

One benefit of the O'Dell group's work would be to find those scientific observations which could be done quickly and used to show the public and the other science team members that the Hubble Space Telescope did have a strong capability to perform valid and important scientific investigations.

Yet another committee was formed under Dr. Weiler to reevaluate the NASA policies regarding observing time guarantees to Hubble project scientists and how those policies should be altered to insure fairness to those scientists whose observations couldn't be done at the current time and to those whose scientific objectives could be met now.

Following the June 27 press conference, a decision was made to keep the press informed on a very timely basis and weekly teleconferences were set up between members of the press and Hubble project managers and scientists. These telecons encouraged questions and provided answers directly to reporter's inquiries — on the record and openly.

One of the strengths of this type of press interaction is the ability to quell rumors at a very early stage and insure that the media are receiving accurate and official information rather than speculation.

Hubble and the Press

A particularly vexing problem for the scientists and managers who participate in the press telecons is the press' impression that the Hubble Space Telescope is "crippled" or "dead" because of the spherical aberration problem. Dr. Weiler and the other Hubble team members participating in the press telecons continually remind the media and its members that though the aberration is a significant problem, it is not preventing the Hubble telescope from performing important science and that profound discoveries are expected still to be made using Hubble telescope instruments in their current state.

To be fair to the press, Weiler and the others on the project side admit there will be a loss of some of the imagery which Hubble was specified to be able to take, but there will be no loss of scientific discoveries and the pictures will come about naturally through two concurrent mitigating activities. The first involves the use of computer enhancement techniques which may be able to compensate partially for some loss of image quality in the Wide Field/Planetary Camera and Faint Image Camera instruments and which would enable pictures from these instruments to be taken and released to the public between now and 1993. The second is the first replacement instrument for the imaging science disciplines — the Wide Field/Planetary Camera II and it should be ready for duty with corrector mirrors in place by 1993.

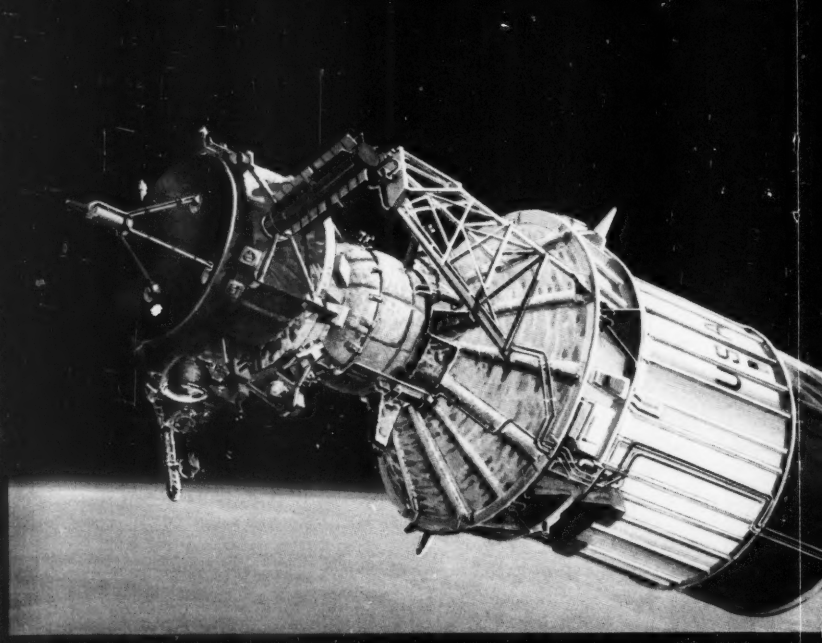
Stunning Images

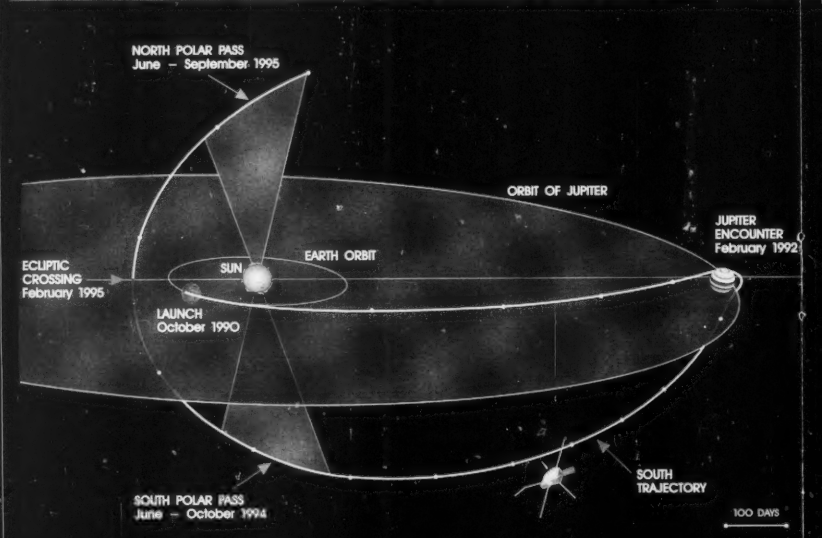
And, according to Dr. Weiler, despite the loss of most of the Wide Field/Planetary Camera science objectives for the near term, that instrument and the Faint Object Camera may still surprise the press and the public with stunning images in the near term. ■

Notes on Spherical Aberration: Spherical Aberration occurs when the light which reflects off a mirror's surface (or which is refracted through a lens' glass) comes to a focus at different distances. Light hitting the outside of the mirror focuses at one point and light bouncing off the inner surface of the mirror focuses at a different point.

The Mission of the Sun-Chasing

The Long Hoped-for Journey into Un-navigated Solar-Polar Space Begins





lysses is a joint mission between the United States National Aeronautics and Space Administration and the European Space Agency to explore the heliosphere over the full range of solar latitudes, especially above the Sun's poles. It is the first space journey out of the solar ecliptic plane.

The goal of the Ulysses mission is to provide an accurate assessment of our total solar environment.

The space craft will be launched in October 1990 by the STS-41 Shuttle Discovery, and the Payload Assist Module/Inertial Upper Stage will place the spacecraft on an ecliptic transfer orbit to Jupiter.

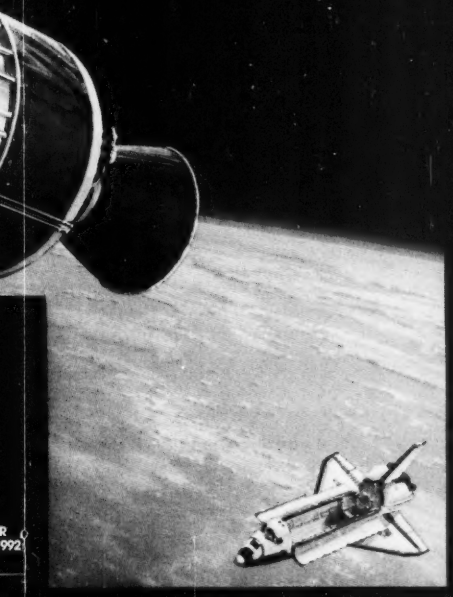
On its outward journey, Ulysses will perform interplanetary physics investigations and, during two periods when the Earth is directly between the spacecraft and the Sun, searches for gravitational waves will be conducted. Upon arrival at Jupiter, approximately sixteen months after launch, Ulysses will measure the Jovian magnetosphere.

Ulysses will use the massive Jovian gravitational field to deflect the spacecraft trajectory out of the ecliptic and will then travel in a high inclination orbit toward the Sun's south pole, reaching previously uncharted heliographic latitudes.

The most intense scientific activity will commence with the first polar pass, about three and a half years after launch. As the spacecraft passes through 70 degrees south solar latitude, at about twice Earth's distance from the Sun, nine scientific instruments on board will collect information, as a function of solar latitude, about the solar corona, the solar wind, the heliospheric magnetic field, cosmic radiation from outside the solar system, and other solar and interstellar particles and fields.

continued on page 14

Ulysses



Major Mission Events
Launch Period:
October 5-23, 1990
Launch Vehicle:
Shuttle/IUS/PAM-S
Jupiter Flyby: February 1992
First Polar pass (above 70 S Solar Latitude): May-October 1994
Second Polar Pass (above 70 N Latitude): May-September 1995
End of Baseline Mission:
September 1995
End of Baseline Project:
March 1996

Notes from the Project Scientist

By Ed Smith, JPL

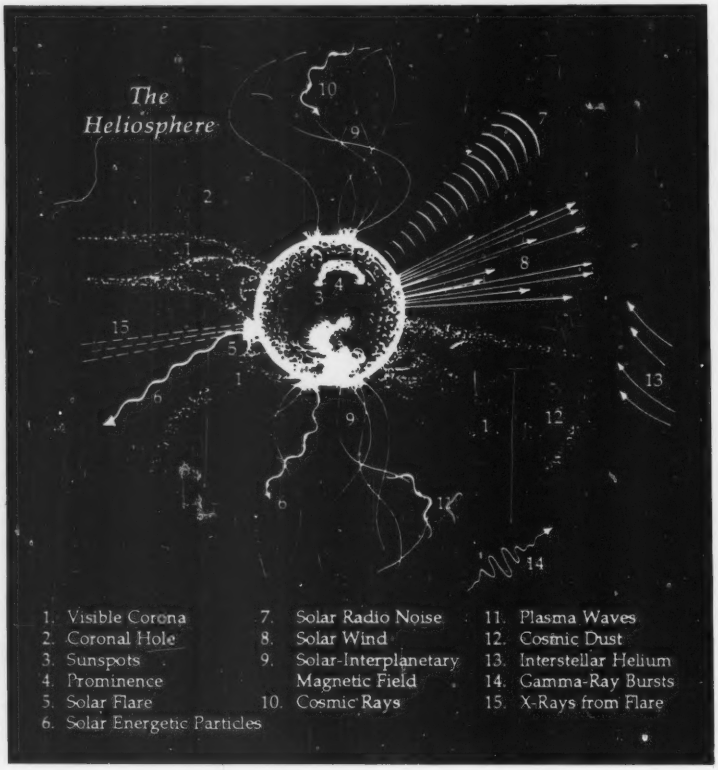
The Ulysses mission, scheduled for launch in October, will fulfill a long standing desire of space scientists to explore the unknown regions above the sun's poles. It could not be undertaken, however, until means were found to overcome the difficulties of launching from Earth which is traveling rapidly around the sun near the solar equator. Ulysses will be launched at high speed, targeted to Jupiter and its elliptical orbit will be reoriented by the gravitational field of that massive planet to pass over the sun's poles at a distance of approximately 186 million miles.

A major scientific objective is to investigate the outermost atmospheric layer of the sun (the corona), parts of which are continuously escaping to create the solar wind. In the polar regions, this outflow is thought to be simpler and more steady than in the equatorial zone in which all previous measurements have been made. This simplicity is thought to be a feature of minimum solar activity which will be the phase of the solar cycle when Ulysses is above the poles. Accordingly, extrapolation of the measurements back to the sun may be much easier and could reveal physical conditions in the polar caps. The extent to which the solar wind impacting the Earth, often causing magnetic storms and aurorae, originates in the polar regions will be studied. The sun's polar cap magnetic field will be mapped for the first time. Waves, which can contribute energy and momentum to the solar wind at its source or be generated within the solar wind after it leaves the sun, will be studied.

The solar wind sweeps the ionized component of the nearby interstellar medium out of the solar system to form what is called the heliosphere. However, some interstellar constituents can penetrate inside this bubble-like volume, namely, electrically neutral particles, dust and cosmic rays, which are atomic nuclei accelerated to near the speed of light by cataclysmic events occurring elsewhere in our galaxy. Ulysses will reveal the extent to which interstellar particles, especially the cosmic rays, have more ready access to the polar regions and could drastically improve our knowledge of their properties outside the heliosphere.

The energization of particles by the sun and in the solar wind will be studied from a polar perspective, as will X-rays and radio waves from solar active regions. Spacecraft radio signals will be used to probe the solar corona. The galactic sources of ultra high energy bursts of electromagnetic radiation (gamma rays) will be sought. A search will be carried out for gravitational radiation generated by the motion of massive astrophysical bodies such as black holes.

Thus, the comprehensive field and particle measurements made possible by Ulysses will provide new and basic information regarding aspects of the sun's behavior, the origin of the solar wind including the portion in which the Earth resides, the nearby interstellar medium and signals coming from the galaxy. Most important of all, it will reveal the physical phenomena occurring in these diverse regions of space, which scientists are expecting to contain numerous surprises. ■



***Ulysses,* from page 12**

In response to the sun's gravitational pull, Ulysses will then arc toward the solar equator and cross it at about one astronomical unit (Earth's distance from the sun.) Though scientific investigations will continue throughout this period, interest will peak again when the spacecraft reaches high northern heliographic latitudes.

About five years after launch, Ulysses will have explored the heliosphere at nearly all latitudes, measured phenomena over both of the sun's poles and investigated interplanetary particles and fields. As the spacecraft leaves the region of the sun's north pole, the mission will end.

Mission Objectives

• Gain knowledge of interplanetary medium at high solar latitudes due to the solar chromospheric and photospheric conditions, sunspots, solar flares, prominences, and coronal holes

• Characterize various particles from the ecliptic to the sun's poles, including: solar wind, galactic cosmic rays, interplanetary dust, and solar energetic particles

• Analyze the heliospheric medium from the ecliptic to the poles, including: plasma waves, solar radio waves, and heliospheric magnetic fields

• Secondary objectives: interplanetary physics investigations on the journey toward Jupiter, measurement of the jovian magnetosphere, and a search for gravitational waves from cataclysmic cosmic events ■

***Commentary,* from page 4**

no greater inspiration to our children than the challenge and opportunity to explore the unknown—and ultimately live on another planet.

I can promise that the excitement and romance of space provides both the challenge and inspiration for youngsters like nothing else in their lives. It gives them a reason to want to learn.

They now know that what they can dream, they can someday make happen—if only they want it badly enough. The dreams of our forefathers thousands of years ago—the desire to know and understand—are now within the reach of our children. They will not be denied. The implications on education in the use of space as a motivational tool for learning are, indeed, far reaching.

The next giant leap in space need not be solo—the first voyage to Mars might well be an international effort involving many countries. Still there is great risk to our economic security if the U.S. does not have a stable and ambitious space program of our own. If we back off and say "we've done it all, we've gone to the moon and developed the space shuttle", and let others build upon our technological competence, we will find ourselves in an unacceptable position both politically and economically. We cannot afford not to be in position to influence the course of the next giant leap in space and ultimately to determine our own destiny.

As President Bush recently reminded us, "History tells us what happens to nations that forget how to dream." Let Congress know that there is too much at stake to turn back now. What we leave undone today will certainly be done by others tomorrow. ■

CENTER HIGHLIGHTS

No-Frills People Carrier Being Designed at JSC

By Billie Deason, JSC

What weighs only 20,000 pounds, carries 10 people to low-Earth orbit, has no wings but returns to dry land?

A simple, rugged people carrier, known as a personnel launch system (PLS), that is being designed as part of an agencywide study sponsored by Headquarters' Office of Space Flight (OSF).

With a limited number of shuttles to support the long-term operation of Space Station Freedom and future exploration missions, agency planners believe a dedicated personnel vehicle could complement shuttle services. The people carrier would be launched on a conventional rocket, complete its mission in low-Earth orbit, then fly home on its own, preferably to dry land.

Safety and life-cycle efficiency are the two priorities of the design project. "We were asked to focus on simple shapes without wings, and to use existing technology," said Andy Petro, lead engineer for the JSC version of the PLS. Boeing Aerospace of Seattle supports Petro's team.

The study began in March 1989 with OSF setting the ground rules and reviewing the initial design concepts.

Marshall Spaceflight Center is designing the PLS launch vehicle. The rocket will have a launch capability at least equal to that of a Titan IV. Kennedy Space Center (KSC) furnishes vehicle processing and launch systems expertise to the other centers' design teams. Langley Research Center is designing another version of the people carrier in the shape of a lifting body with large fins. In the overall course of the study, spacecraft shapes ranging from simple capsules to winged gliders will be considered.

"We've settled on a biconic-shaped capsule as the JSC reference design," said Wayne Peterson, co-designer of the JSC PLS. The biconical (meaning two cones placed end to end) shape offers a large open volume and provides the most practical shape for connecting a service module.

"For the PLS, we might be talking about as many as 12 vehicles as opposed to three or four shuttles, so we really have to change how we think about space flight operations," Petro said. A 20-year lifetime is projected for the PLS program. In determining the number of vehicles needed, one goal is to provide for a smooth processing flow. It may be cheaper to build more vehicles and avoid the constant pressure of a round-the-clock vehicle turnaround operation.

A launch escape system is a basic requirement for the PLS. "In an emergency, the capsule would be pushed away from the rocket by four solid rockets housed in a launch adapter, then descend on a parachute into the water.

A typical mission—for instance, a space station crew rotation—would take two or three days. A small cargo area is included in the design to accommodate passengers' personal items. "We could carry small, high-value, critical cargo if it were necessary," Peterson said.

JSC's people carrier concept.

The craft is designed to seat eight passengers and two crew for operating the PLS's control systems. Because the PLS will be highly automated, the extent of flight crew involvement has not yet been determined.

The JSC team's current design uses a small drogue chute followed by a large parafoil canopy that expands outward from the center in three stages, ending in a full flare for landing. The biconical PLS then settles to Earth on large airbags under the aft end, with the nose coming to rest on a deployable, surfboard-sized skid.

"We expect the space shuttle and future multi-purpose vehicles like it to have a continuing role in manned space flight," Petro said. "But there may also be a need for more specialized vehicles, like the PLS, as part of a growing space transportation fleet." ■

Wallops Celebrates 45 Years of Aerospace Research

By Keith A. Koehler, WFF

A Wallops crew prepares sounding rockets for a 1970 total solar eclipse mission.

Among the marshes of Virginia's Eastern Shore fly a variety of wildfowl such as geese and ducks. Since 1945 birds of a different feather have been known to rise from the area — rockets from the launch pads of Wallops Island.

On April 25, 1945, Congress approved funds for the construction of a test station under the direction of the Langley Aeronautical Laboratory of the National Advisory Committee for Aeronautics.

Two months after construction began, on July 4, 1945, a Tiamat research rocket lifted off the launch pad, beginning a long history of innovative aerospace research techniques from what is now known as the Goddard Space Flight Center's Wallops Flight Facility.

Over the years, the facility and work conducted at Wallops has undergone many changes. With the establishment of NASA in 1958, Wallops became an independent center known as Wallops Station. Wallops was to undergo two more name changes in its history, the Wallops Flight Center in 1974, and its current title came with the consolidation with Goddard in 1981.

In the early years, the research focused on obtaining aerodynamic data at very high speeds as part of the effort to penetrate the sound barrier and operate at supersonic speeds. In the late 1950s and early 1960s, component development tests for manned spacecraft such as the escape and recovery techniques and maximum dynamic pressure-tests (Little Joe series) were conducted at Wallops. With the use of the Scout launch vehicle, many small satellites, atmospheric reentry tests, and space probes have been launched from Wallops.

The hallmark of Wallops has continued to be its suborbital research projects. Home to Goddard's Suborbital Projects and Operations Directorate, Wallops sounding rockets, scientific balloons, and aircraft provide scientists with unique avenues for conducting science and research worldwide. The three flight platforms provide reliable, relatively inexpensive means for conducting research in space science and Earth observations.

The Observational Science Branch of the Laboratory for Hydrospheric Processes, also based at Wallops, is actively studying the interaction of the oceans, atmosphere, and weather. Part of this effort is involved in the development of instruments for advanced Earth monitoring satellites.

The sounding rocket program conducts an average of 35 missions each year, with a fleet consisting of 15 different vehicles types ranging from 10 to 64 feet in length. These one-to-four-stage vehicles fly vertical trajectories carrying their payloads from 30 to 800 miles altitude.

Wallops manages the NASA Balloon Program including management of the National Scientific Balloon Facility in Palestine, Texas. An average of 35 scientific balloon flights are made each year from NSBF and other locations.

Balloon and sounding rocket campaigns are supported in other areas around the world. A permanent balloon launch site has been established at Ft. Sumner, New Mexico, permanent sounding rocket facilities are used at White Sands Missile Range and a contract with the University of Alaska provides for operation of the Poker Flat Research Range. Personnel using mobile equipment have conducted campaigns in Arctic and Antarctic regions, South America, Africa, Europe, Australia, and aboard ships.

Wallops also operates a fleet of six different scientific platform aircraft which conduct nearly 150 research missions each year.

From a few dozen employees in 1945 to the nearly 1,000 in 1990, Wallops people have maintained a dedication to applying inexpensive and innovative methods to scientific research. ■

Wallops Conducts Rocket Campaign in Kwajalein

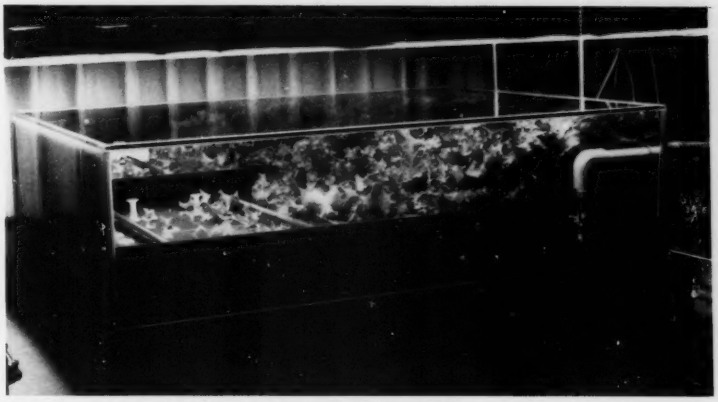
NASA is conducting a sounding rocket campaign in the South Pacific over the summer to better understand the Earth's ionosphere in the equatorial regions and the response of the ionosphere to electric fields and plasma cloud injections.

The Wallops Flight Facility (WFF), Wallops Island, Va., planned to launch seven suborbital sounding rockets from the Roi-Namur launch facility in the Kwajalein Atoll in the Republic of the Marshall Islands.

Four of these sounding rocket experiments complement the science objectives of the Combined Release and Radiation Effects Satellite (CRRES). CRRES is a joint NASA/U.S. Air Force mission to study the Earth's magnetic field and the effect of space radiation on advanced electronics. The remaining three sounding rocket experiments comprise the Equatorial Ionospheric Studies (EQUIS) program.

The sounding rockets carry experiments designed to study a region of the ionosphere from 155 to 372 miles above the Earth. The experiments aid scientists in understanding the chemistry and spatial structures of the ionosphere and the fundamental physics of ionosphere disturbances and turbulence in the equatorial regions.

The campaign scientist is Dr. Michael Mendillo of Boston University, and the campaign manager is Jay F. Brown of WFF. Seventy-two people from Wallops and the science community will be involved in the campaign. ■



Produce grows in Ames "space farm" model.

Fresh Veggies for Space Flight

By Jane Hutchison, ARC

The first working model of a "salad machine" that eventually will provide a variety of fresh vegetables for astronauts on long voyages is now growing its first crop at NASA's Ames Research Center, Moffett Field, Calif.

Dr. Mark Kliss, project manager and principal investigator, said one of the first things astronauts and submariners ask for, following days or weeks of eating freeze-dried or preserved foods, is fresh produce. "Our goal is to produce such a variety of fresh salad vegetables for consumption by the crews of Space Station Freedom and other long-duration missions," Kliss said.

The presence of plants and the ability to "cultivate" a garden also can improve the crew members' morale by providing something for them to nurture and by offering a creative outlet during their free time, much like tending a garden on Earth, he said.

Garden-variety plants such as leaf lettuce, carrots, radishes, onions, sprouts, tomatos, peppers and cucumbers are being considered for inclusion in the salad machine. Most candidate vegetables have very similar temperature, humidity, lighting and nutrient requirements, thus simplifying the environmental control system. Because of limited space, some plants will be smaller than the varieties commonly found on Earth.

Tomato plants, for example, will be less than 12 inches high. And because there is no gravity, some of the vegetables will grow "upside down" or "sideways," although in the weightlessness of space there is no true "up" or "down."

Kliss' goal is for the salad machine to produce three salads per person per week for a crew of four. It also will recycle the water transpired by plants back into the nutrient delivery system. Eventually, Kliss hopes the salad machine can use recycled water to grow plants and produce potable water for crew consumption.

It also will furnish oxygen-enriched air to the cabin environment after particulates and excess water vapor are removed. Food production, carbon dioxide scrubbing, oxygen generation and water purification are key functions of the "bioregenerative" life support systems being developed by the Advanced Life Support Division at Ames. ■

Marshall Volunteers Test Space Station Water Purification System

By Mike Simmons, MSFC

About 50 Marshall and contractor employees have begun volunteering an hour a day exercising, cooking meals, washing dishes and clothes, and showering—all to help develop and test the water purification portion of the Environmental Control and Life Support System for Space Station Freedom.

Each day for about an hour each, a series of three volunteers at a time enter an "airlock" into a small chamber in Marshall's End-Use Equipment Facility (or EEF). Once through the simple airlock, which is designed to control and protect the facility's atmosphere, they step into a small, encased room made of metal materials that are similar to what will be used for actual station construction. The EEF was built to provide a simulation of flight hardware.

Inside, the volunteers begin to exercise on rowing, skiing, stair climbing and treadmill machines. As they continue their vigorous workouts, special condensing heat exchangers collect from the air gases and perspiration their bodies give off, capturing moisture for processing into water later.

When they've finished their exercises, the volunteers clean up in special showers and turn in their exercise clothing (made to simulate outfits the Space Station Freedom crews will wear) for washing, using more water the Environmental Control and Life Support System equipment must filter and clean for reuse. At times, they'll also be asked to microwave a meal in the EEF (which will approximate the release of cooking vapors in Freedom's galley) and then clean their dishes in the facility's dishwasher.

Equipment in the EEF, such as the clothes washer and dryer, dishwasher, and microwave oven, have all been modified by NASA and contractor e[illegible] more closely represent [illegible] aboard Freedom, said Dr. [illegible] Humphries, chief of Marshall's Thermal Engineering and Life Support Division that is performing the current testing. He said other equipment has been built and installed to collect and process urine. The water vapor collected from the subjects' perspiration and respiration will be turned into potable (drinkable) water. The water derived from the dishwasher, clothes washer and dryer, whole body shower, handwasher, and urinal will be processed back into the hygiene water for reuse for those same purposes.

Marshall researchers work up a sweat in water purification tests.

"No reclaimed water will be returned to the EEF or come into direct contact with the test subjects," Humphries said. "Before the test subjects will be permitted to reuse the cleansed water, it will undergo extensive testing to insure its purity."

"This is an extremely exciting project where we're pushing technology beyond where we've been before," Humphries said. "It's a real challenge to develop a system that can serve the Space Station Freedom well and perhaps also pave the way for life support systems that will make possible a long-term lunar base and exploration of Mars. We're working hard to make it safe and dependable." ■

JPL Tests Planetary Rover

By Jim Doyle, JPL

Scientists and engineers at NASA's Jet Propulsion Laboratory, Pasadena, Calif., have begun an extensive period of field testing of a semi-autonomous navigation system on a computer-operated robotic vehicle prototype for possible use in future planetary explorations.

Brian Wilcox, supervisor of the Robotic Sensing and Perception Group, said the summer-long testing program would be carried out mostly in the Pasadena Arroyo, a dry river bed, adjacent to JPL.

Developing new technologies, including a new generation of planetary rovers, is seen as critical to the success and cost effectiveness of the Space Exploration Initiative (SEI) program announced by President Bush in July, 1989. The Planetary Rover project will develop systems for the manned and unmanned vehicles needed for surface transportation.

Surface transportation systems required by SEI include unmanned rovers for outpost site survey and for regional robotic exploration and science, piloted rovers for transportation both locally and long range, and unmanned cargo handling, construction and mining.

Increased traverse distance, longer life and autonomous operations are required for the unmanned roving vehicles for the program. Traverse distances of up to several kilometers per Earth day and a mission life from one to five years are desired for the next generation of robotic exploring vehicles.

The operation of an autonomous unmanned rover in a location remote from the Earth, such as the surface of Mars, with round-trip communications time, at the speed of light, between eight and 40 minutes, involves an entirely unproven technology.

Two advanced forms of unmanned rover navigation are under development at JPL. They are computer-aided remote driving (CARD) and semi-autonomous navigation (SAN).

The CARD technique allows a human operator to remotely drive a vehicle by planning and identifying an extended (to 100 yards) obstacle-free path with a three dimensional display of images from stereo cameras aboard the vehicle. The path then is transmitted to the vehicle for autonomous execution.

The SAN technique allows a human operator to determine a nominal extended route (up to 30 miles) for the vehicle, with the specific path taken by the vehicle around local obstacles determined automatically from the rover's sensor data and stored data base.

JPL's prototype rover made its first, continuous semi-autonomous navigation (SAN) traverse, in rough natural terrain, on May 7, 1990.

The navigation testbed is a six-wheeled, three-body, articulated vehicle the experimenters call Robby. It is about 13-feet long, 5-feet wide and more than 6.5-feet high. Its 35-inch diameter wheels and articulated body permit it to go over obstacles a meter high.

The 2,500-pound vehicle contains two computer systems, one for perception and planning and one for control of the actuators in the wheel drive and arm control. The robotic arm has six links and 6 degrees of freedom with an additional pivot axis and gripper providing two more degrees of freedom.

There are four cameras on the pan-tilt head capable of stereo correlation to provide three-dimensional images of objects. A motor generator provides 3,500 watts of power and batteries provide 24 volts. ■

NASA STORY

1915-1990: 75 Years of Aeronautical Research

Pushing the Envelope!

NACA/NASA Flight Research

by Les Dorr, Jr., Hq

Whenever a NASA research pilot completes yet another successful mission, the begoggled, mustachioed spirit of Tom Carroll must smile.

The shapes and faces of flight research have changed dramatically since Carroll, the first civilian pilot hired by the National Advisory Committee for Aeronautics (NACA), performed lift-and-drag studies on a Curtiss Jenny biplane 70 years ago. Yet the premise remains the same: After all the theoretical studies and ground tests on an airplane are done, somebody has to take the thing up to see how it flies.

The NACA was the world's premier aeronautical research organization for more than four decades, but initially most of the flying at the Committee's Langley Memorial Aeronautical Laboratory (today's Langley Research Center) was done with a gaggle of World War I hand-me-downs from the military.

Still, the NACA tested some remarkable machines during the 1920s and 1930s. A Fairchild FC-2W2 monoplane acquired by the Committee in 1928 came with removable wings to allow fitting of a whole series of different airfoil shapes. The Pitcairn Autogiro that Langley operated from 1931-33 may have looked like the misbegotten offspring of a stringbag [illegible]rplane and Uncle Wiggley's [illegible]ip, but it signaled the [illegible]ning of the NACA's [illegible]r-wing studies. After [illegible] America's entry into World War II, NACA flight research geared up to support the nation's military efforts. The fledgling Ames Aeronautical Laboratory (now Ames Research Center) conducted one of the most unusual-and risky-wartime experiments.

The problem: How smoothly would air flow over the wings of the sleek P-51 Mustang fighter? Ames test pilot Jimmy Nissen was towed to 28,000 feet over California's Muroc Dry Lake in a Mustang sans propeller-the prop interfered with engineers' drag calculations-and released. The tow line immediately whipped back and wrapped around the powerless fighter, but Nissen was able to wrestle the plane to a survivable crash landing. No one said NACA pilots didn't earn their pay!

The post-war quest for increased speed and performance filled the skies over Muroc (later home to Edwards Air Force Base and NASA's Ames-Dryden Flight Research Facility) with exotic aircraft. Chuck Yeager and the Air Force's X-1 "Glamorous Glennis" were first through the sound barrier, but NACA pilots also made more than 50 flights in their own X-1 as they methodically explored the rocket plane's subsonic and supersonic characteristics—its "envelope." There were new shapes to test as well.

[illegible] to NACA's understanding of inertial coupling, a violent loss of control about all three axes of flight. The Committee also obtained much useful data on tailless aircraft with the bantamweight X-4 and on the "swing-wing" concept with the pot-bellied X-5. The NACA even had its own record to crow about: On November 20, 1953, Scott Crossfield became the first person to fly twice the speed of sound at the helm of the D-558-2 Skyrocket.

When the NACA era ended on October 1, 1958 with the creation of NASA, the grandest research aircraft of all was already in the

— A NACA/NASA National Legacy

works. The X-15 was NASA's first major aeronautics endeavor, and is considered by many experts to be the most successful flight test program ever. In 199 missions from June 1959 through October 1968, pilots from NASA , the Air Force and North American Aviation (the X-15's builder) flew the winged black beast nearly seven times the speed of sound and as high as 67 miles.

Like most other rocket planes, the X-15 was hauled to launch altitude by a mother aircraft, a B-52 converted specifically for NASA's task. "It shot off the B-52 like a cannon," recalled former project pilot Milt Thompson, now Ames-Dryden's Chief Engineer, "then you had to recover, get the engine lit and cope with the tremendous acceleration."

On high-altitude flights the X-15 soared "like a ballistic missile. You could control your attitude but not your trajectory," Thompson said. "Going 'uphill,' you really couldn't see anything out the window and you had to depend on your instruments. It felt like you were going straight up, even over on your back!"

Another prominent NASA flight research program of the 60s and 70s flew without wings at all. "Lifting body" vehicles paved the way for later craft such as the Space Shuttle and the National Aero-Space Plane (NASP) that are designed to maneuver in the atmosphere during reentry from orbit. The M2 series, the HL-10 and the X-24 not only proved that such configurations would fly successfully, but also convinced Shuttle designers that the hundred-ton orbiter could land safely without heavy jet engines and their volatile fuel.

During the last decade, NASA flight projects have covered a wide range of fundamental investigations and pioneering research. At Langley, a specially modified Boeing 737 helps to develop state-of-the-art computer and communications systems that may find their way into tomorrow's jetliners. Lewis Research Center pilots routinely fly a Twin Otter aircraft into natural icing clouds, gathering data on ice formation and its aerodynamic effects. And Ames-Dryden's X-29, with its unique forward-swept-wings, continues the tradition of the early X-planes by putting information on the shelf for future designers of nimble, high-performance aircraft.

Sometime around the millennium, the X-30 National Aero-Space Plane will lift off the runway at Edwards for a trip into Earth orbit-a "giant leap" toward routine access to space made possible by the trailblazing efforts of NACA and NASA flight researchers over the years. ■

Some NACA/NASA Aeronautical Contributions

1920	1st wind tunnel of NACA, Langley
1926-1929	NACA Cowling developed and tested
1928	High-speed airfoil program begins
1930's	Tricycle landing gear
1935	High-lift flaps
1941-present	Icing research
1940's	Flush riveting
1940's	Transonic Wind Tunnel development
1945-1947	Jet engine research, high-speed aerodynamics leading to the X-1
1945	Variable sweep wings
1946-present	Oblique wing research
1951	"Area Rule" concept developed
1952-1957	Blunt-body/high-drag nose cone
1952-1968	X-15 research aircraft
1960's-1970's	Lifting body research
1960-1969	Runway grooving
1966-1970	Noise reduction through nacelle design
1968-1984	Fly-by-wire
1970's	Winglets
1970's-80's	Highly Maneuverable Aircraft Technology (HiMAT)
1973-1983	National Transonic Facility opened at Langley Research Center, 1983
1975-1989	Advanced Turboprop project
1987	Numerical Aerodynamic Simulator opened at Ames Research Center

BIOGRAPHY

(Biography is written by members of the NASA History Division)

Hugh L. Dryden: NACA/NASA Leader

By William S. Skerrett, Hq

As a young boy in Baltimore, Hugh Dryden saw his first airplane, an Antoinette and was facinated by it. The facination with airplanes never ended.

Hugh Latimer Dryden was born on July 2, 1898, in Pocomoke City, along Maryland's Eastern Shore. In 1907 his family moved to Baltimore and after his encounter with the airplane he began writing many school papers about air and space travel.

Impressed by Dryden's academic achievements, Dr. Joseph S. Ames, head of the physics department at John Hopkins and member of the National Advisory Committee for Aeronautics (NACA), recommended him to the National Bureau of Standards in June, 1918. Under Ames' direction, Dryden worked full-time in the wind tunnel section and studies toward his doctorate in physics and mathematics at night.

Dryden was appointed head of the Aerodynamics Section of the Bureau of Standard's Division of Mechanics and Sound in 1920. His work varied from studying the efficiency of electric fan blades, to airplane propellers, to wind pressures on buildings, to the standardization of golf balls and baseballs. He also continued his own research on turbulence, boundary layer, laminar flow, and wind tunnel turbulence. In 1924, with the aid of Lyman J. Briggs, a future Director of the Bureau of Standards, he began research on airfoil characteristics up to and slightly exceeding the speed of sound. Dryden also developed a way to significantly decrease wind tunnel turbulence, a method employed by the NACA for the development of the laminar flow wing used on the famous World War II fighter, the P-51 Mustang.

Hugh L. Dryden

His many technical articles became must reading for aeronautical engineers and students.

In 1931 he was appointed a member of the NACA's Committee on Aerodynamics.

Dryden's World War II "Bat" glide-bomb for the Office of Scientific Research and Development earned him the Presidential Certificate of Merit.

Dryden also served as the Deputy Director, Scientific, for the U.S. Army Air Force Scientific Advisiory Group headed by Dr. Theodore von Karman. At the conclusion of the World War II, the group was sent to study German scientific wartime efforts. His work produced manuals that became a guide for Air Force research and development for almost ten years.

In 1946 he was appointed Assistant Director of the Bureau of Standards, and the following year replaced the ailing George W. Lewis as the Director of Aeronautical Research at the NACA.

While Director of the NACA, Dryden supervised the forming of the Unitary Wind Tunnel Plan which saved millions of dollars and man-hours of duplicating efforts. He also played a key role in research on STOL and VTOL aircraft, reentry of space vehicles, and development of the X-series high speed research aircraft that culminated with the X-15.

With the Soviet's launch of Sputnik I by the Soviet Union on October 4,1957, Congress and the White House decided to create a civilian space agency. On October 1, 1958, the National Aeronautics and Space Administration (NASA) was formed with a nucleus from the NACA and space-related elements of other government agencies. The directorship, however, did not fall to Dryden but to Dr. T. Keith Glennan, president of the Case Institute of Technology. Glennan insisted, however, that Dryden be appointed the deputy administrator. The passing over of Dryden for administrator was attributed to two reasons. The first was that many people felt there needed to be a "new face" to run the new agency, but the second reason went much deeper. Shortly after Sputnik sent its first beep from space Dryden stated to a House select committee that pumping dollars into the space program would not make up for lost time, and the proposal to send

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NASA NEWS CAPSULES

News Capsules are NASA news releases edited by the Internal Communications Branch, Office of Communications.

Endeavour Tests Underway

Power-on testing on the Space Shuttle Endeavour at Rockwell International Corps Orbiter Assembly Facility in Palmdale, Calif., continues during the eight-month test period started in July. Endeavour's on-board electrical systems are being functionally energized to verify that the vehicle's instrumentation is operational and that vehicle systems are performing to engineering specifications.

Following completion of the power-on tests, a final acceptance test will be conducted to verify the performance of the total integrated vehicle. Endeavour is scheduled for rollout and delivery to NASA in April 1991 and a first flight in early 1992. ■

NASA Features Aeronautics, Space and X-29 at EAA

NASA returned to Oshkosh, Wisconsin this summer, for the 38th Annual Experimental Aircraft Association (EAA) Fly-In Convention with a new exhibit entitled "NASA: Technology for America's Future." The exhibit showcased the technologies being developed for future flight vehicles for safer, more efficient flight and for space science and exploration.

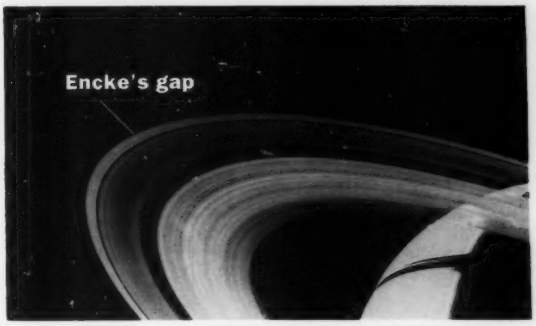
A highlight of the exhibit was the NASA/USAF X-29 forward-swept-wing research aircraft in one of its first public displays away from its Southern California base. NASA's participation also included the return of technical forum speakers and the NASA craftsmanship display.

Supporting the NASA exhibit were the agency's aeronautics field centers, Ames Research Center, Mountain View, Calif., Ames-Dryden Flight Research Facility, Edwards, Calif.; Langley Research Center, Hampton, Va.; and Lewis Research Center, Cleveland.

Goddard Space Flight Center, Greenbelt, Md., provided its SARSAT van, a mobile exhibit that tells the story of the Search And Rescue Satellite System. NASA's AEROVAN traveling aeronautics exhibit also made an appearance.

The exhibit depicted NASA's research on weather-related safety factors such as icing, heavy rain and windshear avoidance, as well as studies involving human interaction in the flight process.

The space science area highlighted NASA's Great Observatories, four missions that may radically alter knowledge about the universe. ■



New Saturn Moon Discovered

A new moon orbiting planet Saturn has been discovered by Dr. Mark Showalter, a researcher at NASA's Ames Research Center, Mountain View, Calif. Showalter found the small, bright object while analyzing images taken by the Voyager 2 spacecraft.

"It was very gratifying to see it," he said. Showalter used a computer program he wrote to sort through 30,000 images sent back to Earth during the Voyager/Saturn encounters in 1980-81.

When the discovery is certified by the International Astronomical Union (IAU), it will bring to 18 the number of Saturnian moons. The new moon has a diameter of only 12 miles and is temporarily designated 1981S13. It orbits in the major gap, known as Encke's gap, in Saturn's outermost major ring, the "A" ring.

Now Saturn's smallest known satellite, the moon pushes material away from its orbit and is believed to cause the 200 mile-wide Encke's gap. The same "shepherding effect," Showalter said, produces Saturn's thin, outermost "F" ring, with moons orbiting on either side of the ring, constraining the material. ■

OMV Program Terminated

NASA has announced the termination of its Orbital Maneuvering Vehicle (OMV) program. Citing budgetary pressures "across the Space Flight realm" for the next several years, together with a lack of firm, near-term requirements for such a vehicle, NASA's Associate Administrator for Space Flight, Dr. William B. Lenoir, concluded that it is necessary to terminate OMV which had been scheduled for a maiden flight in 1995.

As originally conceived, the OMV was to have been a reusable, remotely controlled low-Earth orbit free-flying "space tug". ■

HUMAN FACTORS

Stone Selected as Next JPL Director

Dr. Edward C. Stone, Jr., vice president for astronomical facilities and professor of physics at the California Institute of Technology, has been selected as the next director of NASA's Jet Propulsion Laboratory. He will remain a vice president of Caltech. Stone will succeed Dr. Lew Allen Jr., who is retiring as a Caltech vice president and JPL director. Allen has agreed to serve until December to effect a smooth transition.

JPL is operated by Caltech for the National Aeronautics and Space Administration and leads the world in planetary exploration. The 175-acre laboratory has an annual budget of approximately $1 billion.

"After a national search, we are excited that a man of Ed Stone's drive and vision is in the right place at the right time," Dr. Thomas E. Everhart, president of Caltech, said in announcing Stone's selection. Stone was the unanimous first choice of a distinguished search committee.

Stone will continue as chairman of the board of directors of the California Association for Research in Astronomy (CARA), which oversees all facets of the development of the W.M. Keck Observatory and Telescope in Hawaii.

In 1972, he became the Voyager Project Scientist at JPL. Since the launch of the two Voyager spacecraft in 1977, Stone has coordinated the efforts of 11 teams of scientists in their investigations of Jupiter, Saturn, Uranus, and Neptune. Overall he has been a principal investigator on nine NASA spacecraft and a co-investigator on five others.

Since his first cosmic ray experiments on Explorer satellites in 1961, Stone has investigated the isotopic and elemental composition of galactic cosmic rays and solar flare particles, studied planetary magnetospheres and the interplanetary medium, and collaborated in gamma ray astronomy research.

From 1983 to 1988, Stone served as chairman of Caltech's Division of Physics, Mathematics and Astronomy. ■

Hawley Named for Ames Post

Dr. Dale Compton, director, Ames Research Center, named astronaut Steven A. Hawley as the center's associate director (acting) recently. Hawley assumed his duties July 29 as the center's third-ranking executive.

Hawley has served as deputy chief of the Astronaut Office since 1987 and most recently as mission specialist aboard the Space Shuttle Discovery on mission STS-31 in April of this year. During that flight, he successfully delivered the Hubble Space Telescope to orbit using Discovery's robot arm and extended his total time in space to over 412 hours.

The three-time Shuttle flight veteran was selected as an astronaut in 1978.

He first flew as a mission specialist on the maiden voyage of Discovery, STS-41D, in August 1984. He made his second trip to orbit aboard Columbia on STS-61C in January 1986. ■

Dryden,
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a man into space in a nose cone of a ballistic missile was a mindless propaganda stunt like "shooting a woman out of a circus cannon." Dryden was branded as a man who suffered from a "lack of imagination" by a Congress wanting a quick miracle.

In 1961 the new Kennedy administration determined a reorganization of the national space effort was needed and James E. Webb was selected to replace Glennan. Webb, hesitant in taking the new position, accepted with the condition that Dryden remain the deputy administrator. Dryden stayed on sharing the responsibility for the multi-billion dollar a year space program till his death on December 2, 1965.

Hugh Dryden was a remarkable scientist, an excellent administrator sharing an outstanding rapport with colleagues and employees, a policy maker with exceptional foresight, and a dedicated government official.

Dryden was also a licensed local preacher of the United Methodist Church. He earned spending money through college by delivering sermons and continued to preach and teach evening Bible classes for 45 years. One of his most prized honors was being named the Methodist Layman of the Year for 1962. Devotion to the church was a powerful force in his life, yet he maintained a harmonious balance between science and religion. ■